Safety & Health Guide for the Microelectronics Industry

U.S. Department of Labor
Occupational Safety and Health Administration
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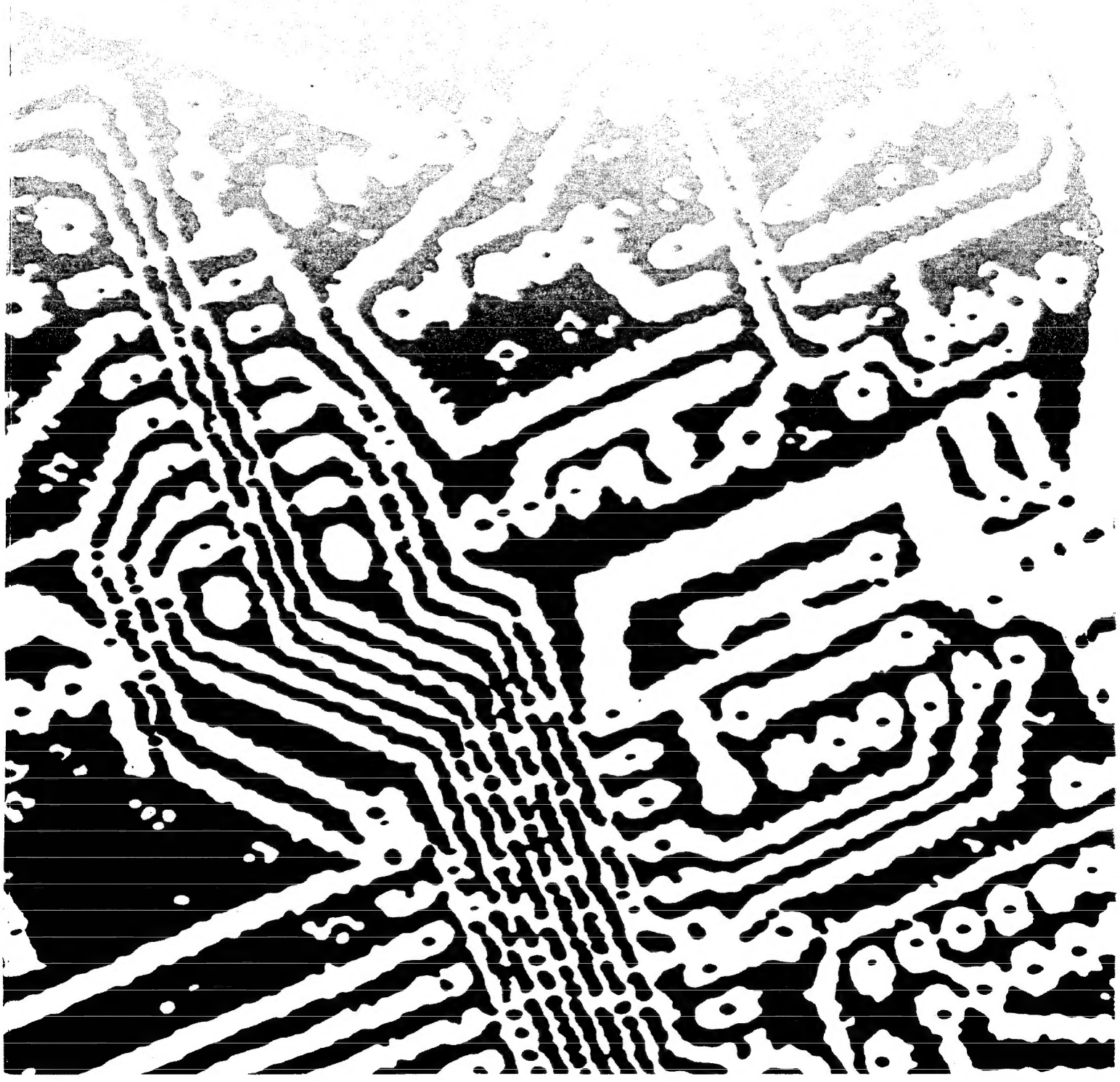

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Abstract
The microelectronics industry employs about 180,000 workers nationally. Of these, about 95,000 are employed in the manufacture of semiconductor components and integrated circuits; about 60,000 are employed in the production of capacitors, resistors, and condensers; the balance manufacture miscellaneous electronics products. The popular impression of this high-technology industry is of employees wearing the white suits in clean, bright comfortable workplaces. Although accurate in many cases, many of the high-tech workers in this industry risk exposure to a wide variety of hazardous substances. Scientific studies conducted in the United States and Europe have identified numerous hazardous conditions and resultant high rates of occupational illnesses within the industry.

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Safety & Health Guide for the Microelectronics Industry

U.S. Department of Labor
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Introduction

The microelectronics industry employs about 180,000 workers nationally. Of these, about 95,000 are employed in the manufacture of semiconductor components and integrated circuits; about 60,000 are employed in the production of capacitors, resistors, and condensers; the balance manufacture miscellaneous electronics products.

The popular impression of this high-technology industry is of employees wearing white suits in clean, bright, comfortable workplaces. Although accurate in many cases, many of the high-tech workers in this industry risk exposure to a wide variety of hazardous substances. Scientific studies conducted in the United States and Europe have identified numerous hazardous conditions and resultant high rates of occupational illnesses within the industry.

Many microelectronics production processes involve chemical interactions, chemical cleaning, and various light and radiation exposures. Most work is completed on an assembly line with a very fine level of detail and precision. Hazards range from acute and chronic exposures to toxic chemicals, to radiation and electric shock, and to stress and fatigue.

Briefly, hazards can be categorized as resulting from exposure to solvents, alkalis, metals, gases, vapors, radiation, and from workplace stress. In addition, other potential hazards that employees and employers should be aware of include falls, overexertion, sprains/strains and injuries from stationary objects or from being caught in, under, or between objects.

This publication is designed to encourage electronics industry employers to review and strengthen overall safety and health precautions to guard against workplace accidents, injuries, and illnesses. It contains discussions of the various hazards in the industry and the various means of controlling them to protect exposed workers. Control measures may be reviewed by Compliance Safety and Health Officers (inspectors) of the Occupational Safety and Health Administration (OSHA) during workplace inspections to evaluate employer safety programs, particularly in the areas of accident prevention and emergency response.

This publication also includes a list of acutely toxic chemicals whose presence in the workplace should signal the need for stringent safety and health measures to protect workers (see Appendix).

Although the following discussions focus on the conditions and processes found in the electronics industry, including (but not limited to) firms in Standard Industrial Classification (SIC) 3674 (Semiconductors and Related Devices) and 3679 (Electronic Components), they are written for a variety of workplaces that produce similar industrial and consumer products.

OSHA also publishes a manual entitled, "How to Prepare for Workplace Emergencies" (OSHA 3088), which can help any type of business in developing an emergency plan. A single free copy may be obtained from any OSHA Regional Office, listed in this publication.

Potential Hazards

In this industry, production workers are those most frequently exposed to hazardous conditions. Nearly every production job involves the use of chemicals for cleaning, stripping, or degreasing parts and equipment. Maintenance personnel who enter enclosed or confined spaces are also exposed to toxic substances.

Solvents

Solvents are used to dissolve various materials. Those commonly used include trichloroethylene, toluene, acetone, methylene chloride, perchloroethylene, glycol ether, isopropyl alcohol, chloroform, xylene, and freon. Exposure occurs by skin absorption and by inhalation. Skin exposure may result in dermatitis or skin rash, edema or swelling, and blistering. These exposures can result from chemical splashes and spills, from directly immersing one's hands into solvents and chemicals, from contact with solvent-soaked clothing or solvent-wet objects, and from the use of improper personal protective equipment. Solvents can dissolve the body's natural protective barrier of fats and oils leaving the skin unprotected against further irritation.

In addition, the inhalation or absorption of solvents may affect the central nervous system, acting as depressants and anesthetics causing headaches, nausea, drowsiness, dizziness, complaints of irritation, abnormal behavior, general ill-feeling, and even unconsciousness. These symptoms should be viewed as visible signs of potential disease. Excessive and continued exposure to certain solvents may result in liver, lung, kidney, and reproductive damage, as well as cancer.

Acids and Alkalis

Acids and alkalis are used for electroplating, soldering, making fluxes, crystal polishing, and metal pickling. These substances may cause serious burns if they are splashed into the eyes or onto the skin. If vapors or mists are inhaled, they may result in a burning of the linings of the nose, mouth, throat, and lungs.

Metals

Metals are used for electroplating, etching, soldering, bonding, sealing, crystallizing, depositing, and metallizing. Employees are exposed to metals primarily by skin contact and by inhalation of metal dusts and fumes. Exposure may cause headaches, general ill-feeling, anemia, central nervous system and kidney damage, and reproductive problems, as well as cancer.

Gases

Gases are utilized in doping and crystal growing, and may combine with other substances to produce toxic gases such as phosgene, ozone, and carbon monoxide. Workers can be exposed to these gases if there are leaks in machines or enclosures. Potential exposure to gases occurs through inhalation. Such exposure may produce eye damage, headaches, shivering, tiredness, nausea, and possible kidney and liver damage.

Plastics and Resins

Plastics and resins are part of several high tech processes. Inhalation or skin contact may occur when curing resins; cutting, heating, or stripping wires; or cutting, grinding, or sawing a hardened product. Exposure to these substances may result in skin rash and upper respiratory irritation.

Polychlorinated Biphenyls (PCBs)

PCBs are used as insulators in some electrical equipment and present a potential hazard to workers. Exposures to PCBs may cause skin disorders, digestive problems, headaches, upper respiratory irritations, reproductive problems, and cancer.

Fiberglass and Asbestos

Fiberglass and asbestos are also used as fillers in epoxy resins and other plastics, in wire coatings or electrical insulation, and in printed circuit boards. Uncontrolled exposures may produce skin and upper respiratory irritations and, in the case of asbestos, cancer.

Additional Hazards

Radiation, noise, and occupational stress are also hazards to which workers in this industry can be exposed. Job stress can result from prolonged repetitive and monotonous detail work, overtime and work speed-ups, as well as from lifting, improper sitting, and prolonged standing.

Noise Exposure The employer must monitor noise exposure levels whenever employees are exposed to noise at or above 85 decibels (dB) averaged over 8 working hours—that is, an 8-hour time-weighted average (TWA). Employees or their representatives are entitled to observe monitoring procedures and they must be notified of the results.

Audiometric testing must be made available to all employees who are exposed at or above levels of 85 dB over an 8-hour TWA, and the audiometric testing follow-up should indicate whether hearing loss is being prevented by the employer's hearing conservation program.

Hearing protectors must be available to all workers exposed to a TWA of 85 dB or greater at no cost to the employees, and employers must assure that all employees exposed to or above the equivalence of 8-hours of noise of 85 dB use them. Workers must be trained at least annually in the effect of noise, in the purposes, advantages, and disadvantages of various types of hearing protectors as well as in the selection, fit and care of protectors, and the purpose and procedures of audiometric testing.

Electric Shock Electricity travels in closed circuits, normally through a conductor. Shock occurs when the body becomes a part of the electric circuit. The current must enter the body at one point and leave at another. Shock normally occurs in one of three ways. The person must come in contact with (1) both wires of the electric circuit, (2) one wire of an energized circuit and the ground, (3) or a metallic part that has become "hot" by being in contact with an energized wire, while the person is also in contact with the ground.

Employees and others working with electrical equipment need to follow safe work practices. These include deenergizing electrical equipment before inspecting or making repairs, using electrical tools that are in good repair, using good judgment when working near energized lines, and using appropriate protective equipment.

Carpal Tunnel Syndrome The carpal tunnel syndrome (CTS) is a disorder of the hand which can afflict circuit board assemblers. The carpal tunnel is a channel in the wrist through which the median nerve and nine tendons pass. Flexing and extending the wrist moves the tendons back and forth against the canal, which can cause irritation and swelling of the tendons. This, in turn, causes pressure against the median nerve. This nerve entrapment at first commonly causes numbness and tingling in the fingertips. A frequent symptom is "nocturnal numbness," a lack of sensation at night when activity has ceased and muscle movement does not help pump blood to the fingertips. As the problem becomes more serious, the employee can suffer from an inability to grip, clumsiness, muscle atrophy, and constant wrist pain.

Most employees and employers do not recognize CTS as a work-related disorder. If not diagnosed swiftly or if complications set in, CTS can cause lengthy or permanent disability. Research sponsored by the National Institute for Occupational Safety and Health (NIOSH) proves that hand/wrist cumulative trauma disorders were strongly associated with high-force, high-repetitive work, and to a lesser extent with high repetitiveness or high force alone, irrespective of other factors.

Safety and health officials emphasize the prevention of CTS by using special tools, changing the work station and surface, matching employees with fewer CTS factors to repetitive tasks, or rotating employees, thereby reducing the average exposure to a highly repetitive task. These types of changes can provide important side benefits such as increased productivity and reduced employee fatigue.

Control Measures

Engineering Controls

The seriousness of health effects is dependent upon the particular substance and the amount to which the worker is exposed, the duration of the exposure, how often the exposure occurs, and how the substance enters the body (skin absorption, inhalation, or ingestion).

The preferred way of controlling potential occupational safety and health hazards is through the implementation of engineering controls. Engineering controls prevent harmful worker exposure through proper design of equipment and processes. Frequently, engineering controls are not built into the physical design of a particular plant and have to be installed later. Types of workplace engineering controls that can be implemented include closed systems, process change, isolation, wet methods, and ventilation.

Closed Systems Where possible, work that involves potentially hazardous exposures should be performed in closed systems. Closed systems require that materials to be processed be brought into the workplace in sealed containers and be emptied into storage tanks, thus preventing employee contact or exposure to the substance. Glove boxes or other similar containment devices also may be appropriate when working with such substances. Unfortunately, not all operations lend themselves to such an approach.

Changing a Process Another way to control hazards is to change a work operation to minimize worker exposure. For example, vapor degreasing could be accomplished with dip tanks having adequate ventilation controls rather than by manually washing parts in open containers.

Isolation Where possible, hazardous work can be isolated or enclosed to reduce employee exposure. An example is the use of acoustic panels to reduce noise. The isolated equipment can be operated by remote control from a protected location. The degree of isolation would be determined by the hazard involved, the amount of exposure, and the work patterns.

Wet Methods Wet methods are used to control or reduce dusts that occur during dry processes. This control is widely used because it is a simple, effective, and inexpensive way to minimize potential health and safety hazards. For this control method to work most effectively, appropriate wetting agents must be used and proper procedures should be followed in disposing of waste.

Local Exhaust Ventilation Local exhaust ventilation at the source of a contaminant captures hazardous substances before they escape into the workplace environment. Local exhaust ventilation is the preferred control method because it removes air contaminants from worker's breathing zones. Local exhaust systems should be used when closed systems, isolation, or changing the process are not compatible with the work being performed.

General Ventilation General, or dilution, ventilation systems add or remove air from the workplace to keep the concentration of air contaminants below hazardous levels. General ventilation is simply the normal air flow through open windows or doors, fans, and roof ventilators. General ventilation only dilutes air contaminants, unlike local exhaust ventilation which removes air contaminants. For this reason, general ventilation should not be used to remove large quantities of air contaminants from the workplace or to control major sources of air contamination. When using general ventilation systems, it is important not to recirculate toxic substances throughout the workplace. Another method that can be used when engineering controls are insufficient or not yet installed is administrative control.

Administrative Controls

Worker Rotation One type of administrative control is to reduce employee work periods for jobs that involve exposure to toxic substances. For example, employees who have worked for 4 hours at an operation involving exposure to hazardous substances/agents could be transferred or rotated to a less hazardous task for 4 hours, thereby reducing their 8-hour average exposure. Such administrative controls, however, should not be viewed as long-term substitutes for engineering controls, ventilation controls, or other more effective methods of reducing exposures to hazardous substances. Some OSHA standards do not permit worker rotation as a means of keeping their exposures below permissible levels.

Substitution Occasionally, a less hazardous, but equally effective, substance than that being used may be available. If this is so, using the substitute may lessen the hazard.

Personal Protective Equipment

When it is not possible or feasible to eliminate hazardous levels of airborne contaminants from the workplace through engineering or work practice controls, or until they are installed, the employer may have to provide personal protective equipment to workers to reduce or eliminate harmful exposures. Personal protective equipment, however, should be used only when other more effective control methods are not possible. Personal protective equipment does not minimize or eliminate the source of the exposure. As a result, if personal protective equipment fails to work properly, workers suffer immediate exposure to the toxic substance. Personal protective devices include eye and face protection (safety glasses, goggles, and face shields); hearing protection (ear muffs and ear plugs); protective clothing (gloves, coveralls, aprons, and boots); protective skin barriers (creams and lotions); and respirators. The employer must furnish the proper type of personal protective equipment for the specific work operations and exposures. For example, when employees are working with a particular solvent, they should be provided with the appropriate gloves, respirators, goggles, or other protective gear needed to prevent harmful skin contact or inhalation.

An appropriate NIOSH/MSHA (Mine Safety and Health Administration) approved respirator should be selected for the particular hazard or work environment in which the respirator is to be used (e.g., dust masks should not be used to protect against vapor exposures). In addition, the type of air contaminant, its expected maximum concentration, the possibility of oxygen deficiency, the working life of the respirator, and proper respriator fit should be determined before work is begun. Before providing respirators, employers should have the workers' health evaluated by a physician to determine the workers' ability to wear respirators. A thorough respiratory protection training program also must be provided.

Other Protective Measures

Personal hygiene, use of regulated areas (areas where unauthorized employees may not enter), medical surveillance programs, housekeeping, equipment maintenance, and training are other components of a well-designed employee safety and health program that should be considered by the employer.

Personal Hygiene Employers should make handwashing facilities readily available to employees working with or near toxic substances. It is important that workers be able to wash promptly in case of accidental splashes of toxic substances; when appropriate, emergency eye-wash facilities also must be provided. Where called for, convenient access to showers also should be provided. Eating, drinking, and smoking, as well as storing foods, should be forbidden in areas where toxic substances are present.

Regulated Areas Where biological hazards or proven or suspected cancer-causing agents are used or handled, they should be properly marked to inform workers of the potential hazards and the regular and emergency procedures required. Unauthorized persons should not be permitted to enter regulated areas. Employers should also provide workers who enter such areas with a place to change and dispose of contaminated clothing and equipment when they leave. Regulated areas usually are provided with negative-pressure ventilation (i.e., air flows into, not out of, the regulated areas).

Medical Surveillance Medical surveillance is an important part of an employer's safety and health or medical program. It should include a physical examination for all workers consisting of a thorough work history and an examination for ill effects from any exposures to toxic and hazardous substances. Audiometric (hearing) tests must be part of the physical examination when workplace noise levels are above 85 dB for an 8-hour TWA. Results of these exams provide baseline data that, compared with the results of periodic exams, allow detection of the harmful physical effects of particular work operations and evaluation of their severity. Medical records must be maintained by the employer and made available to employees who ask for them.

In addition to periodic medical examinations, workplace exposure monitoring tests should be conducted on a regular basis. Instrumentation that continuously monitors the work environment for airborne contaminants and triggers an alarm when concentrations exceed safe levels should be obtained and used. Use of information from both physical examinations and workplace exposure monitoring can be an effective method of discovering potential occupational safety and health hazards. Workers may also observe monitoring and may review their monitoring records.

Equipment Maintenance All employers should make sure that adequate maintenance schedules are established and adhered to. Poor maintenance of workplace equipment usually causes faulty operation of machinery, which can result in increased workplace accidents and illnesses. A regular maintenance schedule should include periodic shutdowns of all equipment. Employees performing maintenance should be provided with any special personal protective equipment needed for the work.

Good Housekeeping Employers should establish and maintain good housekeeping practices, such as providing a clean and orderly workplace, and facilities for personal hygiene, eating, adequate washing, and waste disposal. Employers must ensure that spills of hazardous substances are cleaned up immediately and that the waste is properly disposed of. Work practices also should be in effect for the safe disposal of toxic chemicals and other hazardous substances.

Training Electronics and semiconductor manufacturers should have effective training programs that deal with employee working conditions. The training should include information on the types of hazards in the workplace, on the adequate coverage of personal protective equipment, on the medical surveillance program, and on emergency situations.

Responding to Workplace Emergencies

In addition to establishing effective safety and health programs, employers should prepare their workers to handle workplace emergencies.

Planning

Top management support and commitment and the involvement of all employees are essential to an effective emergency action plan. Where required by OSHA, plans for firms with more than 10 employees should be written; smaller companies may communicate their plans orally.

Managers should review the plan with employees initially and whenever the plan, or the employees' responsibilities under it, change. The plan should be reevaluated and updated periodically. Emergency procedures, including the handling of any toxic chemicals, should include the following:

- Escape procedures, routes, and exits, designated on maps.
- Special procedures for employees who perform or shut down critical operations.
- A system to account for all employees after evacuation.
- Rescue and medical duties for employees who perform them.
- Means for reporting spills, fires and other emergencies, including names and phone numbers.
- Contacts for further information about the plan.
- A critique of the response and follow-up to ensure that suggested corrections are implemented.

Chain of Command

An emergency response coordinator and a back-up coordinator should be designated. The coordinator may be responsible for overseeing plant-wide operations, performing public relations, and ensuring that outside aid is always available. A back-up coordinator ensures that a trained person is always available. Duties of the emergency response coordinator include the following:

- Determining whether a situation requires activating emergency procedures.
- Overseeing all emergency activities, including evacuating personnel.
- Ensuring that outside emergency services such as medical aid and local fire departments are called in when necessary.
- Directing the shutdown of plant operations when necessary.

Emergency Response Teams

Members of emergency response teams should be thoroughly trained for potential emergencies and physically capable of carrying out their duties in accordance with Title 29 Code of Federal Regulations 1910.120. They should know about the hazards in the workplace and be able to judge when to evacuate personnel or to depend on outside help (e.g., when a fire is too large for the in-house team to handle). One or more emergency response teams should be trained in using the following:

- Various types of fire extinguishers.
- First aid, including cardiopulmonary resuscitation (CPR).
- Shutdown procedures.
- Evacuation measures.
- Chemical spill control procedures.
- Self-contained breathing apparatus (SCBA).

Response Activities

Effective communication is vital in emergency situations. An alternative area for a communications center, other than management offices, should be established in the plan and the emergency response coordinator should operate from this center. Management should provide emergency alarms and ensure that employees know how to report emergencies. An updated list of key personnel and their off-duty telephone numbers should be posted in a convenient place.

A system should be established that requires a person in the control center to notify police or emergency response team members of persons believed missing when a facility has been evacuated.

Effective security procedures, such as cordoned off areas, can prevent unauthorized access and protect vital records and equipment. Duplicate records should be maintained on off-site locations for essential accounting files, legal documents, and lists of employees' relatives to be notified in case of emergency.

Training

Every employee needs to know details of the emergency action plan, including evacuation plans, alarm systems, reporting procedures for personnel, shutdown procedures and types of potential emergencies. Drills should be held at random intervals, at least annually, and include, if possible, outside police and fire authorities.

Training should be conducted initially, when new employees are hired, and at least annually thereafter. Additional training is needed when new equipment, materials or processes are introduced, when procedures have been updated or revised, or when exercises show that employee performance is inadequate.

Personal Protection

Employees exposed to accidental chemical splashes, unknown atmospheres with inadequate oxygen or toxic gases, fires and live electrical wiring, or similar conditions during emergencies need personal protective equipment, including the following:

- Safety glasses, goggles or face shields for eye protection.
- Properly selected and fitted respirators.
- Special body coverings, gloves, hoods and boots.
- Body protection for abnormal environmental conditions such as extreme temperatures.

Medical Assistance

Employers whose workplaces are not near an infirmary, clinic or hospital must have someone on-site who is trained in first aid, have medical personnel readily available for advice and consultation, and develop written emergency procedures.

In addition, in any emergency, first-aid supplies should be available for the trained person to use, emergency phone numbers should be posted in a conspicuous place near or on telephones, and ambulance services should be prearranged and available on short notice.

Hazard Communication

OSHA's hazard communication standard, which applies to the electronics industry, establishes uniform requirements to make sure that the hazards of all chemicals produced, imported, or used in U.S. workplaces are evaluated, and that this hazard information is transmitted to affected employers and exposed employees.

Chemical manufacturers and importers must convey hazard information to downstream employers by means of labels on containers and material safety data sheets (MSDS's). In addition, all covered employers are required to have a hazard communication program to provide the information to their employees by means of container labeling and other forms of warning, MSDS's, and training.

The hazard communication program will ensure that all employers receive the information they need to inform and train their employees properly and to design and put in place employee protection programs. The program also will provide necessary hazard information to employees, so they can participate in, and support, the protective measures instituted in their workplaces.

Recordkeeping

The employer must keep records on exposure measurements and on employee medical examinations. The records on measuring exposure must include a description of the procedure(s); the names, social security numbers, job classifications and exposure levels of employees; the types of protective devices worn and length of time the devices have been in use.

Medical records must include the name, social security number and description of the duties of the employee, a copy of examination and test results, a copy of the physician's written opinion, any employee medical complaints related to workplace substances, a copy of the applicable OSHA standard and appendices, and a copy of the information provided to the physician.

Employee exposure records must be kept for 30 years. Medical records must be kept for at least the duration of employment plus 30 years. Both exposure measurement records and medical records must be made available on request to the Assistant Secretary of OSHA and the Director of NIOSH for examination and copying. Measurement and medical records also must be made available to employees, former employees, or their designated representatives for examination and copying.

OSHA rules require that each employer with 11 or more employees maintain a log of recordable work-related injuries and illnesses (OSHA Form 200). Injuries include those that result in death, loss of consciousness, restriction of work or motion, transfer to another job, or medical treatment beyond first aid. Each injury or illness on the log must be detailed in a supplementary record (OSHA Form 101 or equivalent). Each year, during the month of February, a summary of injuries and illnesses must be posted in the workplace. Records of injuries and illnesses and supplementary records must be retained in each establishment for 5 years following the end of the year to which they relate. These records are valuable for employees because they reflect where serious hazards exist in the workplace. They are important to the employer in analyzing the effectiveness of safety and health programs. They are also important to OSHA inspectors in deciding whether to conduct a complete workplace inspection and, if so, where to concentrate their attention.

Employer and Employee Responsibilities

An employer's commitment to a safe and healthful environment is essential in the reduction of workplace injury and illness. This commitment can be demonstrated through personal concern for employee safety and health, by the priority placed on safety and health issues, and by setting good examples for workplace safety and health. Employers should also take any necessary corrective action after an inspection or accident. They should assure that appropriate channels of communication exist between workers and supervisors to allow information and feedback on safety and health concerns and performance. In addition, regular self inspections of the workplace will further help prevent hazards by assuring that established safe work practices are being followed and that unsafe conditions or procedures are identified and corrected properly. These inspections are in addition to the every day safety and health checks that are part of the routine duties of supervisors.

Since workers are also accountable for their safety and health, it is extremely important that they too have a strong commitment to workplace safety and health. Workers should immediately inform supervisors or their employers of any hazards that exist in the workplace and of the conditions, equipment, and procedures that would be potentially hazardous. Workers should also understand what the safety and health program is all about, why it is important to them, and how it affects their work.

Finally, employers who want help in recognizing and correcting safety and health hazards and in improving their safety and health programs can receive assistance from a free consultation service in their area largely funded by the Occupational Safety and Health Administration. The service is delivered by state governments using well-trained professional staff. The service offers advice and help in correcting problems and in maintaining continued effective protection. In addition to helping employers identify and correct specific hazards, consultants provide guidance in establishing or improving an effective safety and health program and offer training and education for the company, the supervisors, and the employees. Such consultation is a cooperative approach to solving safety and health problems in the workplace. As a voluntary activity, it is neither automatic nor expected. It must be requested. For additional information, contact one of the consultation programs or the nearest OSHA Regional Office listed in this publication.

Appendix

Health Hazards in High-Tech Production

Type of work	Chemicals commonly used	Health effects
Degreasing and cleaning	Methylene chloride	Dermatitis (skin disease), nausea, eye damage
	Methylethyl ketone	Narcosis (stupor, unconsciousness), anesthesia
	Carbon tetrachloride	Depression, suspected carcinogen (cancer-causing agent)
	Trichloroethylene	Headaches, narcosis, nerve damage, suspected carcinogen
Wafer fabrication	Silicon dioxide	Silicosis (dust-caused lung disease)
Wafer doping	Arsenic	Jaundice, liver and heart damage
	Antimony	Tiredness
	Phosphorus	Bone destruction
Wafer diffusion	Phosphine	Vomiting, diarrhea
	Arsenic	Jaundice, liver and heart damage
Photo-etching	Hydrofluoric acid	Skin and eye problems, chemical burns
	Phosphoric acid	Chemical burns
	Hydrochloric acid	Chemical burns
	Nitric acid	Chemical burns
Encapsulation	Liquid epoxy resins	Skin irritants, sensitizer
	Polyurethane plastics	Eye and respiratory tract irritant, sensitizer
	Chloronaphthalenes	Suspected carcinogen
	PCBs	Chloracne (skin disease), liver and kidney damage
Electroplating	Nickel oxide	Dermatitis ("nickel itch"), risk of lung and sinus cancer from inhalation of dust
	Cyanide salts	Dermatitis, eye and respiratory irritant, nausea and vomiting, tiredness
	Chromic acid	Suspected carcinogen
	Cadmium	Water retention in lungs
Drilling and shearing	Fibrous glass	Dermatitis, respiratory damage
Bonding and soldering	Cadmium oxide	Respiratory damage, liver and kidney damage
	Lead oxide	Reproductive hazards, anemia, long-term exposure: brain damage
	Zinc oxide	Respiratory damage
	Zinc chloride	Respiratory damage
Assembly work		Stress, eye strain, fatigue, back strain

Source: Kenneth Geiser, "Health Hazards in the Microelectronics Industry," **Int J Health Serv** 16(1):112, 1986, as compiled from Cindy Talbot and Andrea Hricko, "Hazards of the Electronics Industry" (unpublished material).

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OSHA Consultation Project Directory

State	Telephone
Alabama	(205) 348-3033
Alaska	(907) 264-2599
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Nebraska	(402) 471-4717
Nevada	(702) 789-0546
New Hampshire	(603) 271-3170
New Jersey	(609) 984-3507
New Mexico	(505) 827-2885
New York	(718) 797-7648
North Carolina	(919) 733-2360
North Dakota	(701) 224-2348
Ohio	(614) 644-2631
Oklahoma	(405) 235-0530
Oregon	(503) 378-2890
Pennsylvania	(800) 382-1241 (Toll-free in State) (412) 357-2561/2396
Puerto Rico	(809) 754-2134/2171
Rhode Island	(401) 277-2438
South Carolina	(803) 734-9599
South Dakota	(605) 688-4101
Tennessee	(615) 741-2793
Texas	(512) 458-7287
Utah	(801) 530-6868
Vermont	(802) 828-2765
Virginia	(804) 786-5875
Virgin Islands	(809) 772-1315
Washington	(206) 586-0961
West Virginia	(304) 348-7890
Wisconsin	(608) 266-8579 (H) (414) 521-5063 (S)
Wyoming	(307) 777-7786

H = Health
S = Safety

Related Publications

BLS Publication OMB No. 1220-0029—Recordkeeping Guidelines for Occupational Injuries and Illnesses

OSHA 3084 - Chemical Hazard Communication

OSHA 3047 - Consultation Services for the Employer

OSHA 3088 - How to Prepare for Workplace Emergencies

OSHA 3077 - Personal Protective Equipment

OSHA 3079 - Respiratory Protection

A single free copy of the above publications can be obtained from OSHA field offices or OSHA Publications Office, 200 Constitution Avenue, N.W., Room N3101, Washington, D.C. 20210, (202) 523-9667.

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New York, NY 10014
Telephone: (212) 337-2378

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Gateway Building, Suite 2100
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Philadelphia, PA 19104
Telephone: (215) 596-1201

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230 South Dearborn Street
Room 3244
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Telephone: (312) 353-2220

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(AR, LA, NM,* OK, TX)
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Room 602
Dallas, TX 75202
Telephone: (214) 767-4731

Region VII
(IA,* KS, MO, NE)
911 Walnut Street
Room 406
Kansas City, MO 64106
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(CO, MT, ND, SD, UT,* WY*)
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1961 Stout Street
Denver, CO 80294
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San Francisco, CA 94105
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Room 6003
Seattle, WA 98174
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* These states and territories operate their own OSHA-approved job safety and health programs (the Connecticut and New York plans cover public employees only and OSHA currently is exercising concurrent private-sector Federal enforcement authority in California).